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(54) **Flame resistant laminate and method of making it**

(57) A flame retardant laminate comprising a flammable substrate, a metal foil adhered to a face of the substrate, and a resin-saturated fibrous web adhered to the foil, the foil being between the fibrous web and the substrate. The web is formed predominantly of fire resistant fibers, such as glass, ceramic, phenolic, carbon, and asbestos. The resin saturating the web is selected from among vinyl compounds, acrylics, polyesters, polyamides, polimides, melamines, phenolics, urea-formaldehyde resins, epoxies, modified cellulosics, and the like. The foil may be of any suitable metal, such as aluminum, having a thickness up to several mils. The substrate may be a construction material such as lumber, plywood, pressed board, chip board, hard board, or an insulative plastic foam.

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The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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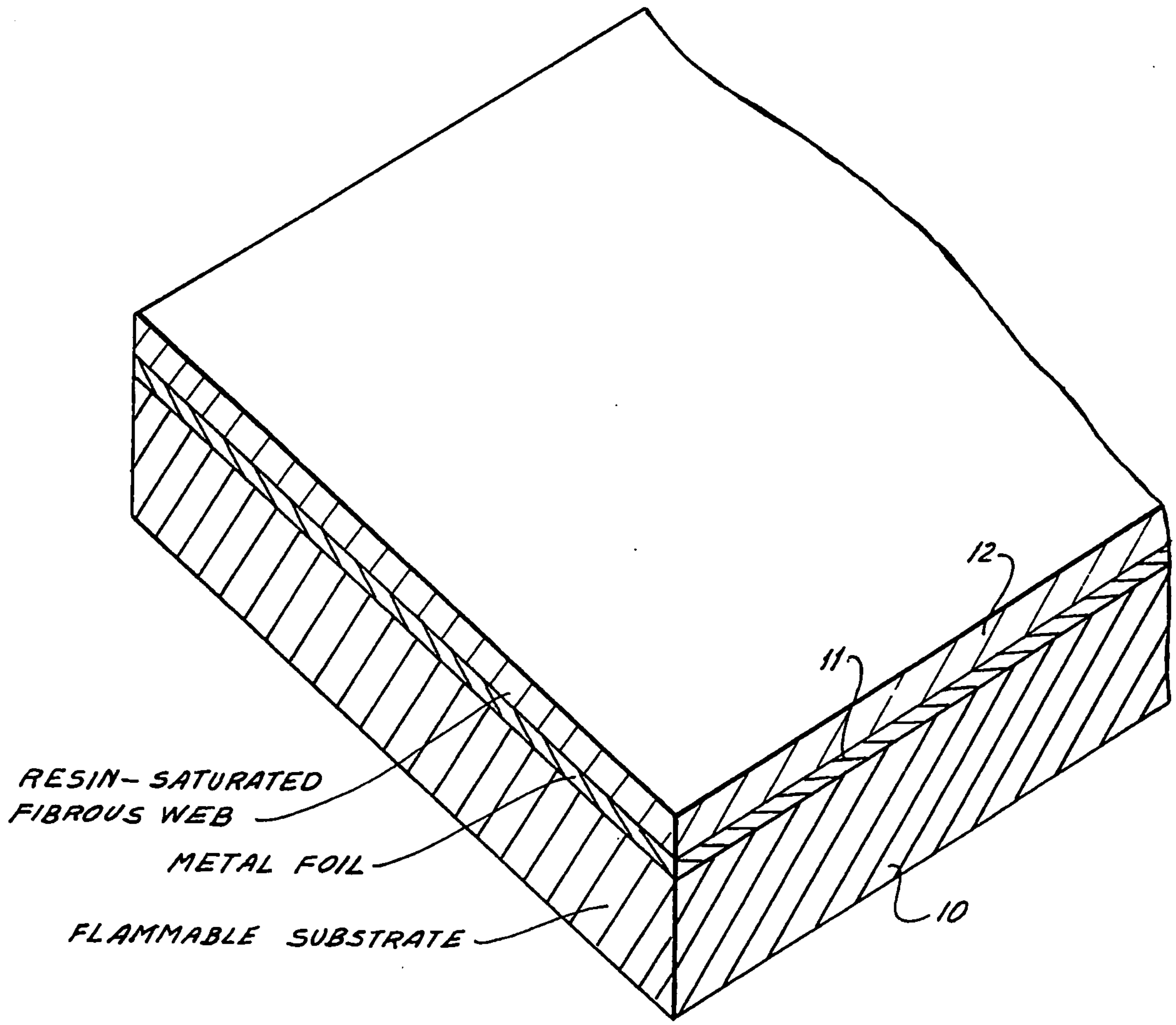

12
11
RESIN- SATURATED
FIBROUS WEB
METAL FOIL
FLAMMABLE SUBSTRATE
10

SPECIFICATION

Flame resistant laminate and method of making it

This invention relates to providing fire resistance to flammable materials, and more particularly to laminating layers of material to flammable substrates so as to protect the substrates from burning when exposed to flame.

Flammability protection in construction materials is needed so that occupants of buildings, automotive vehicles, airplanes, and the like are not exposed to an unnecessarily great hazard from the flammability of the materials which surround them. Great strides have been made in recent years in the field of flammability protection, in part due to more stringent building codes and improved testing criteria. Often, however, the attainment of protection from flammability is achieved only with the sacrifice of other desirable qualities.

For example, nonburning structures made with metal plates suffer from their high weight, lack of corrosion resistance, and difficulty of fabrication. Flame resistant fibrous compositions do not have great durability and are difficult to decorate. Similarly, fibrous, cement, and gypsum boards are lacking in durability and are very heavy when made thick enough to provide significant structural rigidity and strength. Flame resistant paints are available to protect flammable substrates, but they often include toxic or otherwise undesirable constituents. Paints without these undesirable constituents tend to lack durability.

It is an object of the present invention to overcome these problems by providing flame retardancy for flammable construction materials, such as wood or plastic foam, without unduly increasing the weight of the substrate and accompanied by a durable surface for the substrate. It is a further object to provide such flame retardancy using readily available materials.

A feature of the invention involves laminating to the substrate a metallic foil and a resin-saturated fibrous web, the foil being between the substrate and the fibrous web.

Additional objects and features of the invention will be apparent from the following description, in which reference is made to the accompanying drawing. The drawing is a partly perspective, partly cross-sectional view of a flame retardant laminate according to this invention.

Referring to the drawing, the substrate 10 may be any type of construction material which can benefit from being made fire resistant. Adhered to one face of substrate 10 is a layer of metallic foil 11. Adhered to the face of foil 11, opposite the face adhered to substrate 10, is a resin-saturated fibrous web 12.

The substrate may be a material such as lumber, plywood, pressed board, chip board, or hard board, having rigidity and structural strength. The substrate could be an insulating material, such as polystyrene foam, urethane foam, or other plastic foams.

Foil 11 may be formed of any metal having a melting point sufficiently high such that it remains intact when exposed to the heat of an open flame. However, in practice the foil is not exposed directly to flame since it is shielded from flame by substrate 10, on one side, and by web 12, on the other. Foil 11 has a thickness in the range between a fraction of a mil and several mils, and is formed of a metal, such as aluminum, malleable enough to be processed into a foil of such thickness. Any suitable adhesive capable of bonding metal foil to the substrate may be used for that purpose.

Fibrous web 12, which is saturated with a resin, serves the dual purpose of insulating the foil to protect it when the laminate is exposed to flame, and providing a durable and decorative surface for the laminate. The web may be a woven or non-woven material, and is formed predominantly of fire resistant fibers, such as glass, ceramic, phenolic, carbon, and minerals, e.g., asbestos. Non-woven webs may be made by wet-laying the fibers, as in a papermaking process, or by airlaying the fibers in a dry process. Preferably, the web is formed of glass fibers having diameters in the range between one and fifteen microns.

The resin used to saturate web 12 may be of any suitable material, and is selected to meet the requirements of particular applications. For example, a resin may be chosen to provide resistance to ultraviolet light when outdoor exposure is intended, or to resist abrasion when that quality is required. The resin may also be selected for its decorative or decoratable qualities. While the resin need not necessarily be non-burnable, flammability and heat resistance may be considered in choosing the resin employed. Resins suitable for the purposes of this invention include vinyl compounds (e.g., vinylchloride, vinylacetate, and vinylfluoride), acrylics, polyesters, polyamides, polimides, melamines, phenolics, urea-formaldehyde, epoxies, and modified cellulosics.

The resin may be applied to the fibrous web undiluted in any carrier, from solution, from a latex dispersion, or from compounds such as plastisols or organisols. Any suitable adhesive may be used to bond the dry resin-saturated fibrous web 12 to the foil 11. Alternatively, the web, while wet, can be applied to the foil so that the resin, after drying, serves to bond the web and foil together. Preferably, the wet, saturated web, the foil, and the substrate are arranged in face-to-face contact, and heat and pressure then applied to the laminate for a time sufficient to cure the resin.

If desired, pigments may be added to the resin for decorative purposes. In addition, flame retardant fillers, such as antimony oxide and hydrated alumina, may be added to the resin to increase its flame retardancy.

While it is believed that the invention is clear from the description above, it will be further illustrated by the following examples.

Example I

A hardboard substrate, sold commercially under the trademark "Masonite", was coated on one face with a mixture of epichlorohydrin-bisphenol A based epoxy resin and polyamide resin at a thickness of five grams per square foot, the epoxy and polyamide being present in the ratio of three to one by weight. A layer of aluminum foil having a thickness of 0.8 mil was placed on the coated face of the substrate. The exposed face of the foil was covered with a coating of the epoxy/polyamide resin described above at a thickness of 20 grams per square foot. A web composed of 90% glass fibers and 10% wood fibers, which had been made by a wet laid process, and having a basis weight of 60 grams per square meter was placed on the resin coating. The resin was allowed to soak into the fibrous web, and completely saturate it, and then the exposed face of the web was covered with a fluorocarbon-coated release sheet. The laminate was placed in a heated press and pressed with a pressure of 10,000 pounds per square foot at 160° C for a period of seven minutes, at which time the resin was cured. The laminate was removed from the press and the release sheet pealed from the laminate.

Example II

A laminate was prepared in the manner described in Example I, except that the fibrous web had a basis weight of 30 grams per square meter, and the coating thickness of the epoxy/polyamide resin applied to the exposed face of the foil was ten grams per square foot.

Example III

A laminate was prepared in the manner described in Example I, except that a brominated epoxy resin was used in place of the epoxy/polyamide resin, and the laminate was pressed for 20 minutes at 180° C to cure the resin.

Example IV

A laminate was prepared in the manner described in Example I, except that a phenolic resin was used in place of the epoxy/polyamide resin.

Example V

A laminate was prepared in the manner described in Example I, except that an intumescent aminoplast was used in place of the epoxy/polyamide resin.

The laminates of Examples I-V are made according to the present invention. For comparison purposes, laminates were made as described in the following four examples.

Example VI

A laminate was prepared in the manner described in Example I, except that no foil was employed. Instead, the 20 grams per square foot resin coating was applied directly to the Masonite substrate, and the fibrous web placed on this coating. The laminate was heated and pressed as described in Example I to cure the resin.

Example VIII

A laminate was prepared in the manner described in Example I, except that the positions of the foil and fibrous web were reversed. The Masonite substrate was coated with the epoxy/polyamide resin at a thickness of 20 grams per square foot, and the fibrous web placed on the resin coating. After the resin soaked into the web, the foil layer was placed on the web. The laminate was heated and pressed as described in Example I to cure the resin.

Example IX

A laminate was prepared in the manner described in Example I, except that a cellulosic web, i.e., a web made entirely of burnable cellulose fibers, having a basis weight of 34 grams per square meter was used in place of the glass/wood web.

In order to determine the relative resistance to burning of the laminates prepared as described in the preceding examples, a procedure was used as described by H.L. Vandersall in the "Journal of Paint Technology", Volume 39, No. 511, Page 494 (1967). According to this procedure a tunnel is employed having a length of two feet and a width of approximately 6 inches. The tunnel is inclined 28° from the horizontal and laminate samples are placed one at a time into the tunnel. As an ignition source, a Meeker burner is placed one and one-eighth inches from the bottom of each sample, and the gas flow is regulated to a constant 4.82 cubic feet per square inch. Each test is run for a period of four minutes, and the maximum flame propagation down the tunnel is noted.

As reference materials, asbestos-cement board is given a defined rating of 0 and red oak floorboards are given a defined rating of 100. The "Flame Spread" rating for each sample is determined by the following equation:

$$\text{Flame Spread Rating} = \frac{Ls - La}{Lo - La} \times 100$$

Where
Ls= maximum flame travel for the samples
La= maximum flame travel for the asbestos-cement board
Lo= maximum flame travel for the red oak boards

Flammability test results

Example No.	Sample Description	Flame Spread Rating
I	60 GSM web, epoxy/polyamide, foil	61
II	30 GSM web, epoxy/polyamide, foil	40
III	60 GSM web, brominated epoxy, foil	79
IV	60 GSM web, phenolic, foil	95
V	60 GSM web, aminoplast, foil	48
VI	No foil	135+
VII	No fibrous web	Board burned through
VIII	Foil outside web	Board burned through
IX	Cellulosic web, epoxy/polyamide, foil	Board burned through

It will be appreciated from these results that only those laminates having all the essential features of this invention, such as those of Examples I-V, show superior fire resistance. Those features include use of both a resin-saturated fibrous web and a metallic foil layer, locating the foil layer between the substrate and the fibrous web, and using a fibrous web consisting predominantly of fire resistant fibers. Where no foil is used (Example VI), or no fibrous web is used (Example VII), or the fibrous web is located between the foil and the substrate (Example VIII), or a burnable fibrous web is used (Example IX), fire resistance is severely diminished.

If the results of the tests involving the laminates of Examples I and II are compared, it will be noticed that the laminate of Example II had a more desirable Flame Spread Rating than did the one of Example I, even though the laminate of Example I includes a thicker fibrous web. The reason appears to be that the laminate of Example I also includes more resin saturating the web, and it is the burning resin which affected the flame spread ratings. Therefore, a further sample was prepared as described in the following example.

Example X

A laminate was prepared in the manner described in Example I, except that the fibrous web was saturated with a chlorinated polyester resin catalyzed with methylethyl ketone peroxide, a flame retardant resin, instead of with the epoxy/polyamide resin. In addition, the laminate was pressed to a pressure of 10,000 pounds per square foot for five minutes at a temperature of 130°C. When flame tested as described above, the laminate had a Flame Spread Rating of 22.

It will be seen, therefore, that while the invention provides significant fire resistance regardless of the resin employed, use of a flame retardant resin improves the fire resistance of the laminate.

The invention has been shown and described in preferred form only, and by way of example, and many variations may be made in the invention which will still be comprised within its spirit. It is understood, therefore, that the invention is not limited to any specific form or embodiment except insofar as such limitations are included in the appended claims.

CLAIMS

1. A flame retardant laminate comprising:
(a) a flammable substrate,
(b) a metallic-foil adhered to a face of the substrate, and
(c) a resin-saturated fibrous web adhered to the face of the foil opposite the face of the latter which is adhered to the substrate, so that the foil is between the web and the substrate, the web consisting predominantly of fire resistant fibers.

2. A flame retardant laminate as defined in Claim 1 wherein the metallic foil has a thickness between a fraction of a mil and several mils.

3. A flame retardant laminates as defined in Claim 1 wherein the metallic foil is aluminum foil.

4. A flame retardant laminate as defined in Claim 1 wherein the web is the product of a wet-laying papermaking process.

5. A flame retardant laminates as defined in Claim 1 wherein the web is formed predominately of fibers selected from the group consisting of glass, ceramic, phenolic, carbon and asbestos.

6. A flame retardant laminate as defined in Claim 1 wherein the web is formed predominantly of glass fibers having a diameter between one and fifteen microns.

7. A flame retardant laminate as defined in Claim 1 wherein the resin saturating the web is selected from the group consisting of vinyl compounds, acrylics, polyesters, polyamides, polimides, melamines, phenolics, urea-formaldehy

8. A flame retardant laminate as defined in Claim 1 wherein the resin saturating the web is a flame retardant resin.

9. A flame retardant laminate as defined in Claim 1 including flame retardant fillers dispersed in the resin which saturates the web.

10. A flame retardant laminate as defined in Claim 1 including a resin adhesive bonding the foil to the substrate.

11. A flame retardant laminate as defined in Claim 1 wherein the resin which saturates the web also bonds the web to the foil.

12. A flame retardant laminate as defined in Claim 1 wherein the resin which saturates the web has been cured by application to it of heat and pressure.

13. A method of forming a flame retardant laminate comprising the steps of:

(a) applying a metallic foil to a face of a flammable substrate, and

(b) applying to the face of the foil opposite the face of the latter which faces the substrate a resin-saturated fibrous web, the web consisting predominantly of fire resistant fibers.

14. A method as defined in Claim 13 including the step of adhesively bonding the foil to the substrate, and bonding the fibrous web to the foil with the resin which saturates the web.

15. A method as defined in Claim 13 including the step of including a resin adhesive between the foil and the substrate, and subjecting the combined substrate, foil and resin-saturated web to heat and pressure in a direction perpendicular to the plane of the combination until the resin is cured.

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